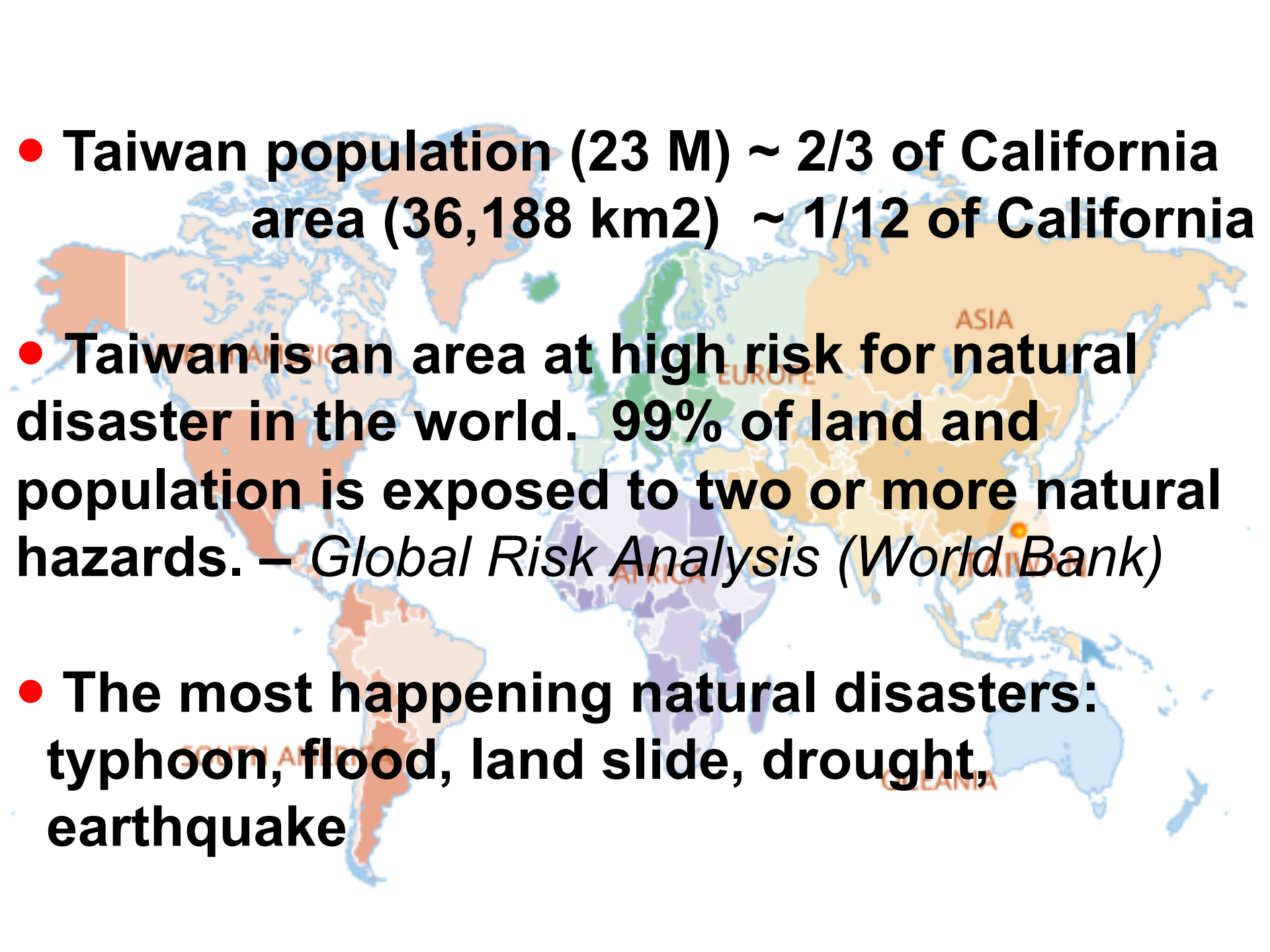


The CWB Monthly and Seasonal Climate Forecast Systems

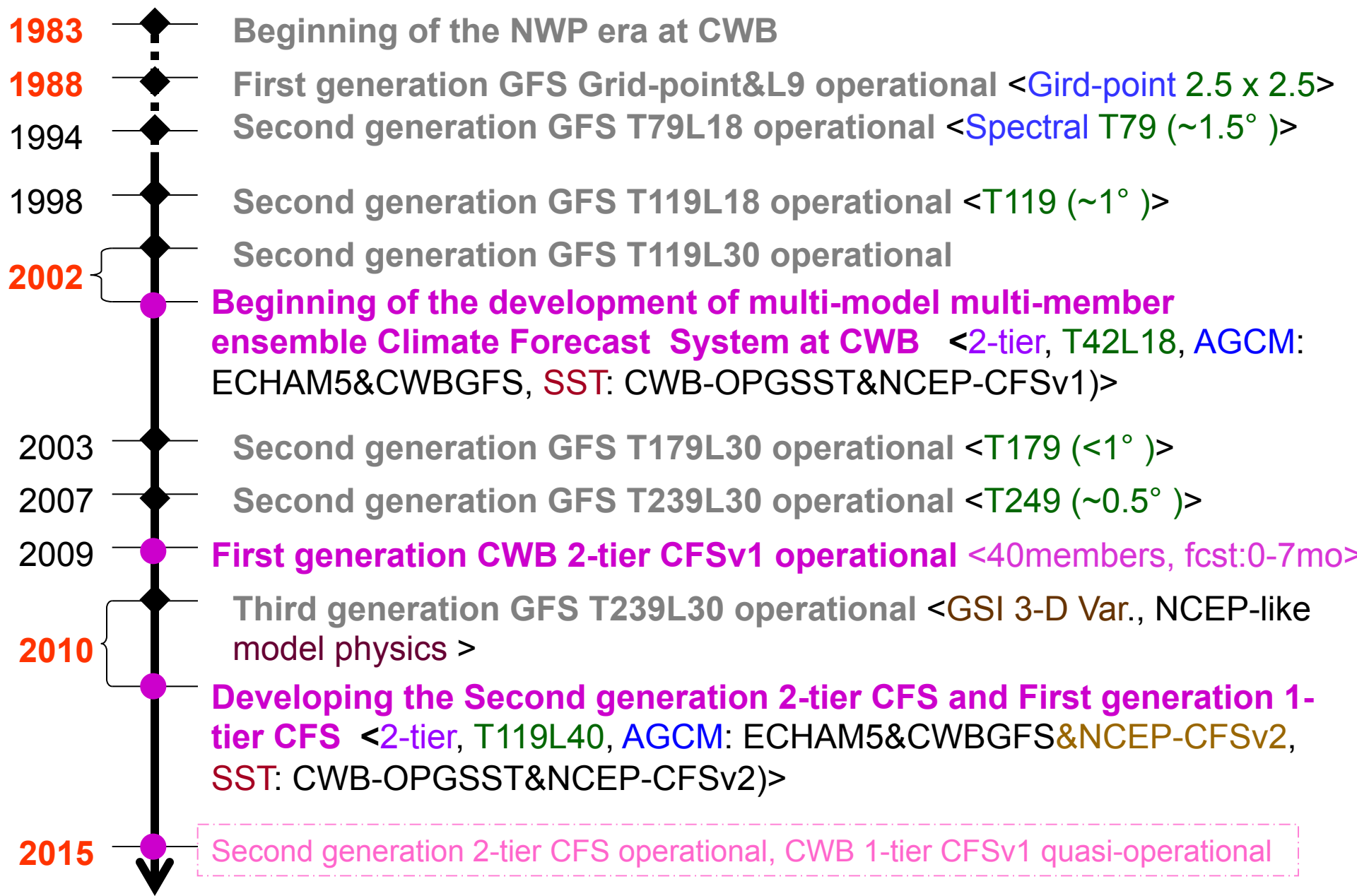
Jhy-Wen Hwu, Mong-Ming Lu, Chih-Hui Shiao, Yea-Ching Tung
Research and Development Center, Central Weather Bureau, Taiwan

CWB NWP GFS modeling team:

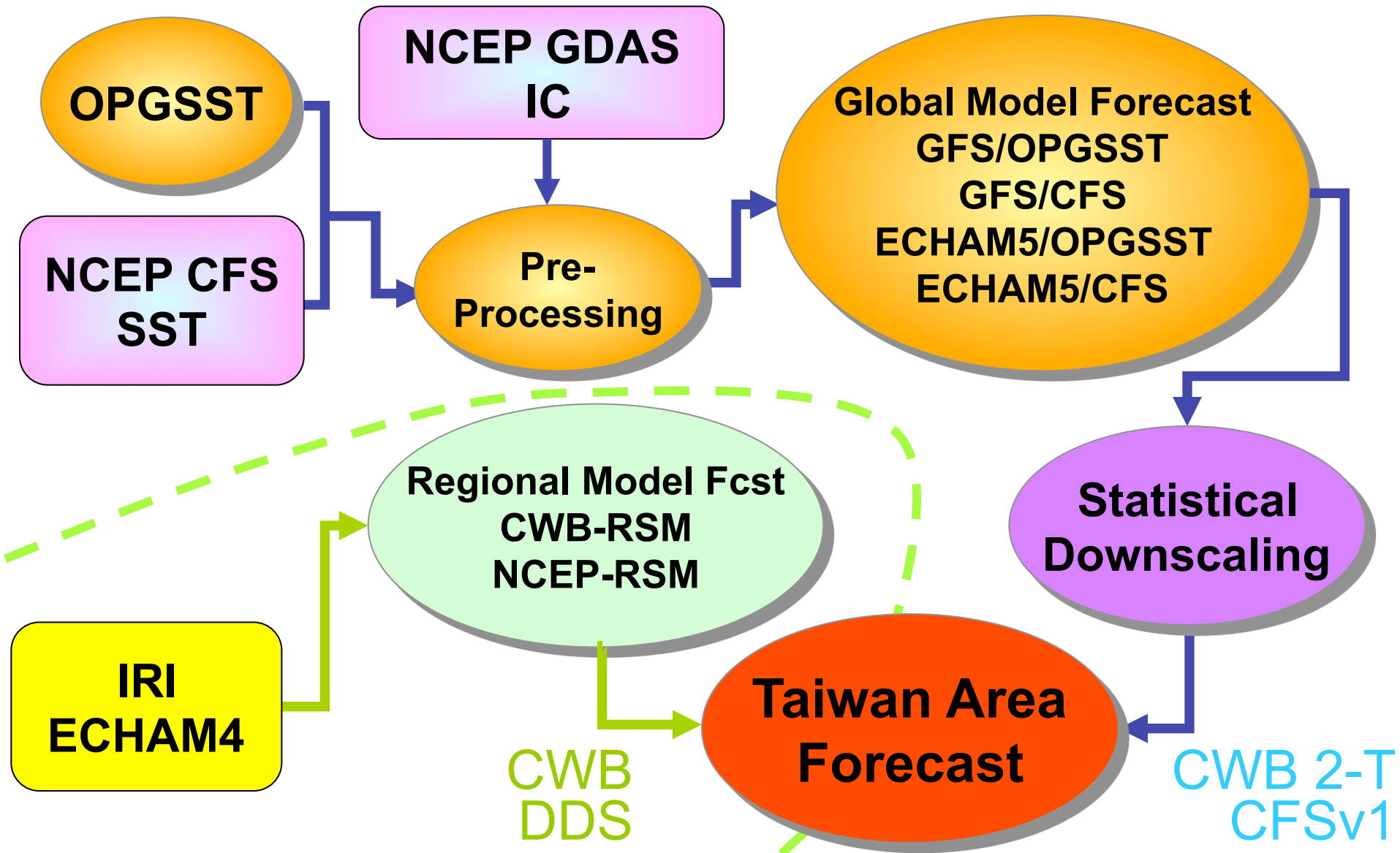
Jen-Her Chen, Chin-Tzu Fong (NWP leader), Fong-Ju Wang

- 
- A world map with continents labeled in orange: NORTH AMERICA, SOUTH AMERICA, AFRICA, EUROPE, ASIA, and OCEANIA. Taiwan is marked with a red dot in East Asia.
- Taiwan population (23 M) ~ 2/3 of California area (36,188 km²) ~ 1/12 of California
 - Taiwan is an area at high risk for natural disaster in the world. 99% of land and population is exposed to two or more natural hazards. – *Global Risk Analysis (World Bank)*
 - The most happening natural disasters: typhoon, flood, land slide, drought, earthquake

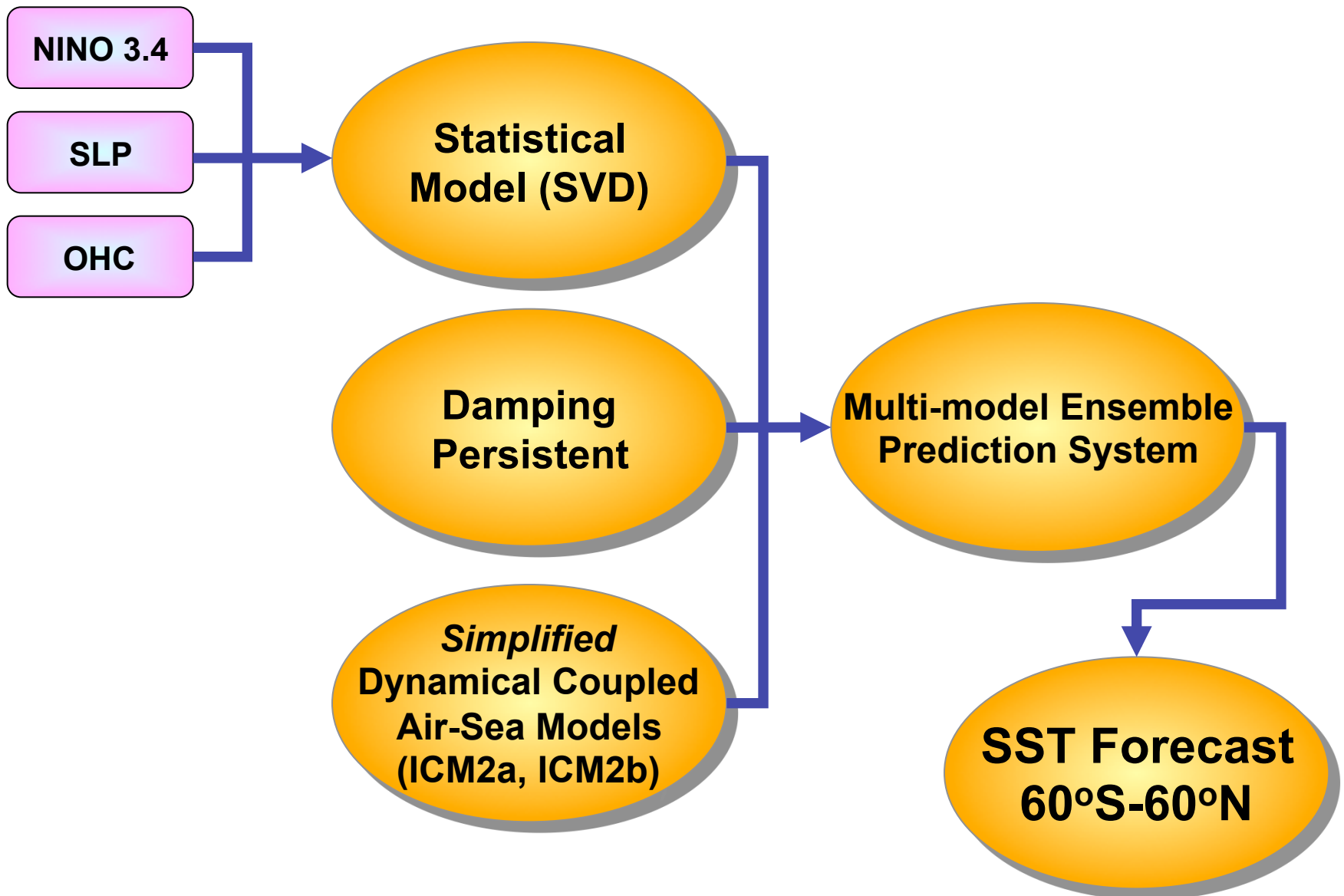
Monthly and Seasonal Climate Forecast – extended development from NWP



CWB 2-tier *seasonal* Climate Forecast Systems



CWB OPGSST



AGCM: CWBGFS and ECHAM5

CWBGFS: **T42L18** (Hwu et al., 2002)

Radiation: Harshvardhan et al.(1987)

Cumulus: relax Arakawa-Schubert scheme(Moothi and Suarez 1992)

Large scale precipitation: RH=100%

Shallow convection: Li(1994)

Vertical turbulence mixing: TKE- ϵ scheme(Detering and Etling 1985)

Surface flux: similarity theory(Businger 1971)

Soil model: two layer soil model (Mahrt and Pan 1984)

Gravity wave drag: Palmer et al.(1986)

ECHAM5: **T42L19** (Roeckner et al., 2003)

Radiation: Shortwave Fouquart and Bonnel (1980) ;

Longwave Mlawer et al. (1997)

Cumulus: Tiedtke (1989) with modifications of Nordeng (1994) for penetrative convection

Grid-scale precipitation: Tmopkins (2002)

Vertical turbulence mixing and surface flux: similarity theory

Subgrid scale orography parameterization: Lott and Miller (1997) and Lott (1997)

Gravity wave drag: Hines (1991a, b, c, 1993)

Dynamical Downscaling

IRI-ECHAM4.5 (T42) forecasts
with forecast SST (15)

CWB-RSM (60km)
(15)

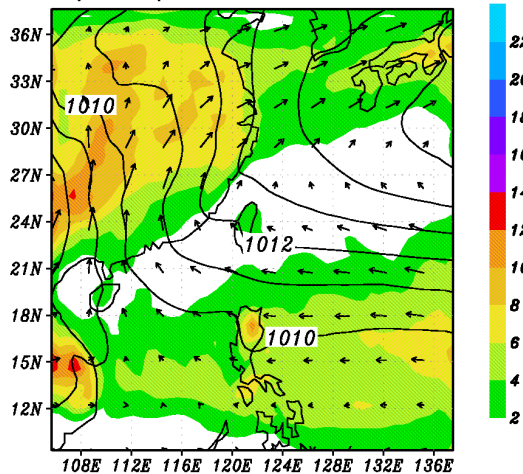
NCEP-RSM (60km)
(15)

Ensemble mean forecast
(30)

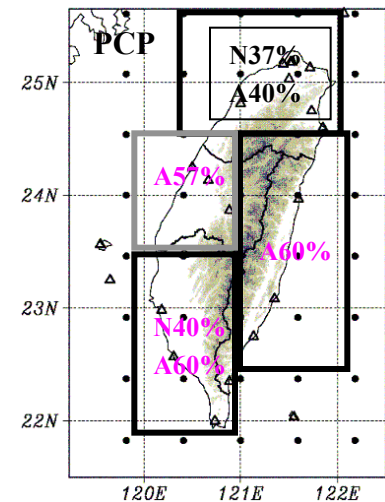
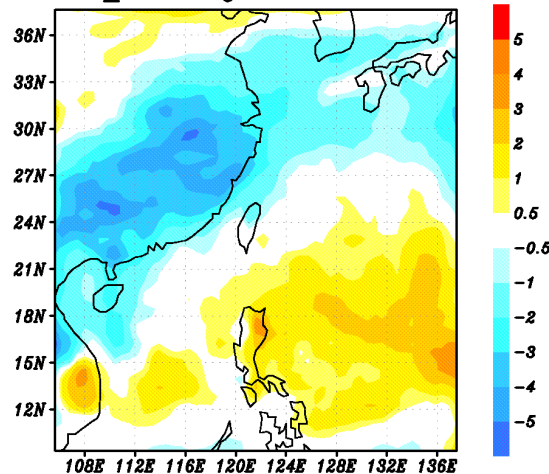
Anomaly forecast
(30)

Probability forecast
(30)

PCP/MSLP/W850 200804 RCMs MAY

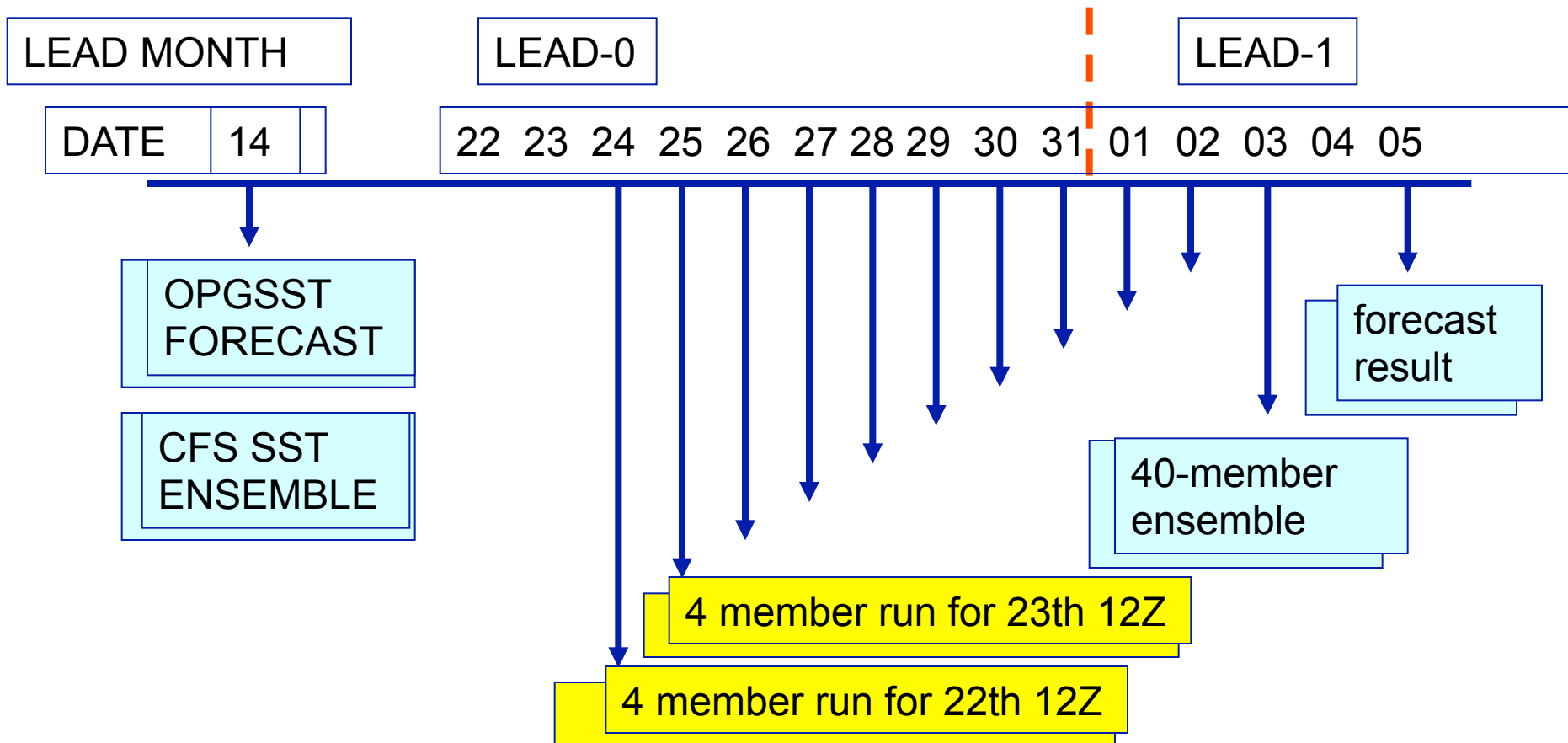


PCP_anomaly 200804 to MAY



Data Used	Link	Variables	Frequency (/ month)
NCEP GDAS	ftp:// ftpprd.ncep.noaa.gov/ pub/data/nccf/com/gfs/ prod/gdas.\$yy\$mm\$dd/	Mean sea level pressure / Geopotential height / Temperature / Specific humidity U-wind / V-wind	20
NCEP R1	ftp://ftp.cdc.noaa.gov/ Datasets/ ncep.reanalysis.derived/ pressure ftp://ftp.cdc.noaa.gov/ Datasets/ ncep.reanalysis.derived/ surface	U-wind / V-wind (monthly mean) Mean sea level pressure (monthly mean)	1
NCEP OI SST	ftp://ftp.cdc.noaa.gov/ Datasets/ ncep.reanalysis.derived/ surface ftp://ftp.emc.ncep.noaa.gov/ prod/ftp/	Sea surface temperature (monthly mean)	1
CAWCR Ocean	ftp://ftp.bom.gov.au/ ANALS	14 layer ocean temperature data	1
NCEP CFSv1 SST	ftp://tgftp.nws.noaa.gov/ SL.us008001/ST.opnl/ MT.cfs_MR.fcst	Sea surface temperature	once a day
NCEP CMAP	ftp://ftp.cdc.noaa.gov/ Datasets/cmap/enh	precipitation (monthly mean)	1

Operational Forecast Schedule



- IC: last 10 days of lead0 from NCEP/GDAS.
- 4 members run in all IC+2 days (GFS/OPGSST, GFS/CFS, ECHAM/OPGSST, ECHAM/CFS) with 7 months forecasting.
- Each member need about 40 minutes for model running and another 30 minutes for post process.

Retrospective Forecast Data Base

- *Background Statistics* -

- 25 years: 1981-2005
- 40 forecasts per calendar month
- Each forecast predicts 9 months

Forecast Skill Evaluation

- Pattern Anomaly Correlation
- Temporal Correlation
- Mean Square Skill Score
- Gerrity Skill Score
- ROC
- Relative Diagram

CWB 2-T CFSv1 FORECAT PRODUCTS

- **Global SST (60°S~ 60°N)**

issuing frequency: 1 time/month

lead time: 0-7 months

product format: monthly, seasonal

- **Global Temperature, Precipitation**

issuing frequency: 1 time/month

lead time: 0-7 months

product format: monthly, seasonal

- **Taiwan Temperature, Precipitation**

(downscaled to 9 stations)

issuing frequency: 1 time/month

lead time: 0-7 months

product format: monthly, seasonal

(dynamical downscaling – downscaled to 4 regions)

issuing frequency: 1 time/month

lead time: 0-4 months

product format: monthly, seasonal

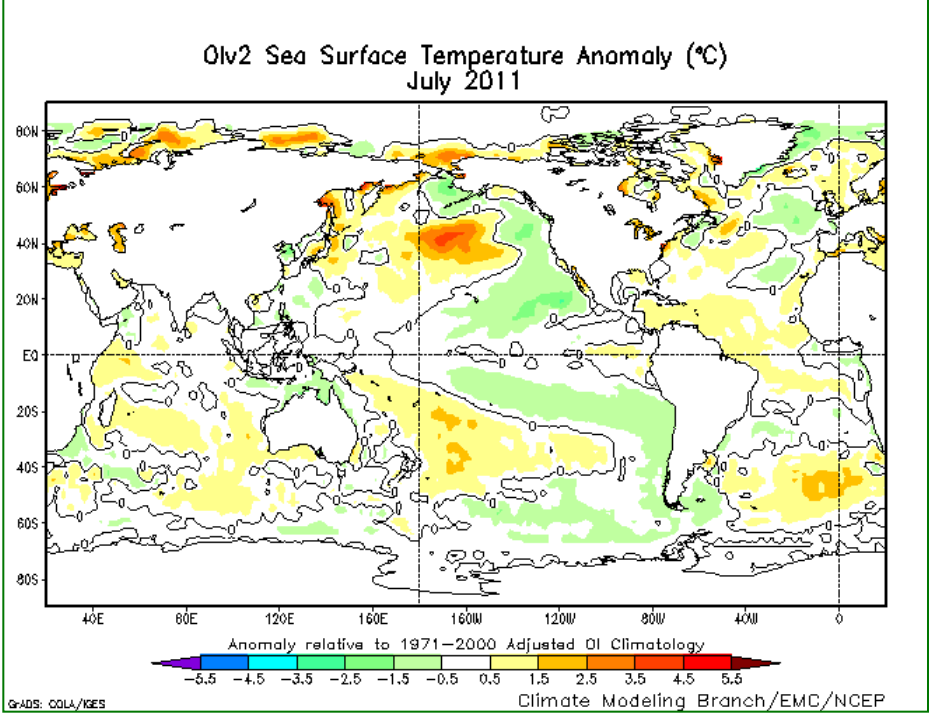
Calibration Basis ~

CWB 2-tier CFS Hindcast/

Forecast Data Base:

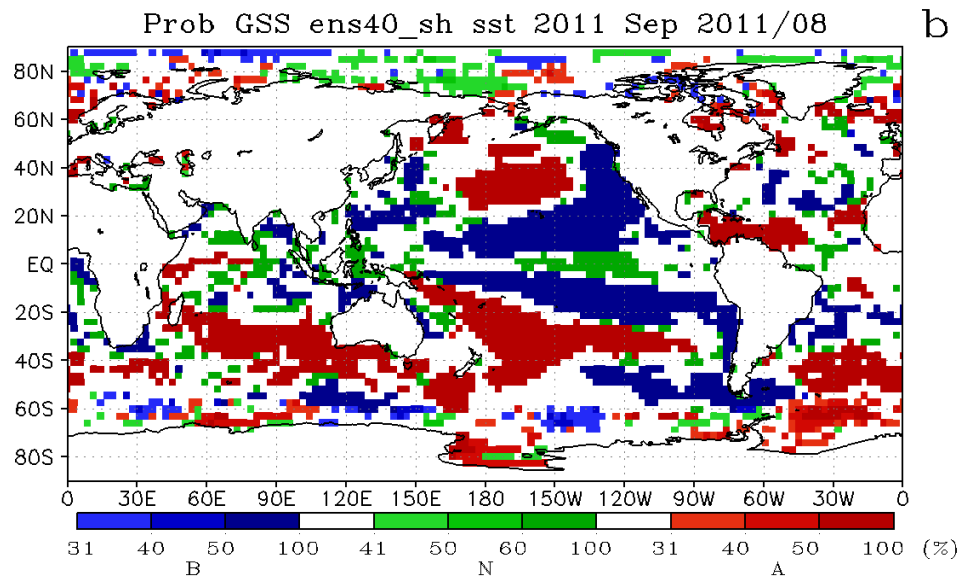
1981-present daily outputs at
standard pressure levels

Observation: Jul 2011 (lead 0)

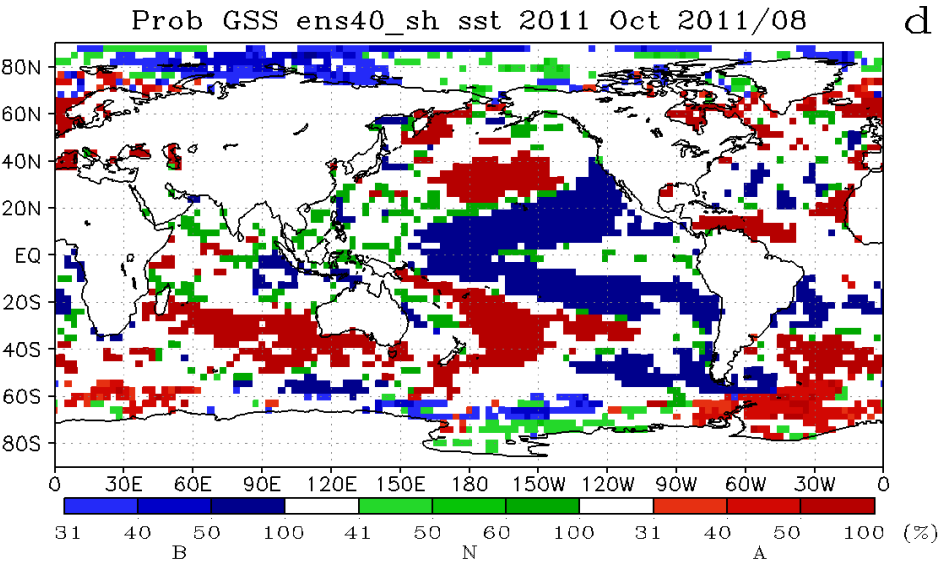


Sea Surface Temperatures

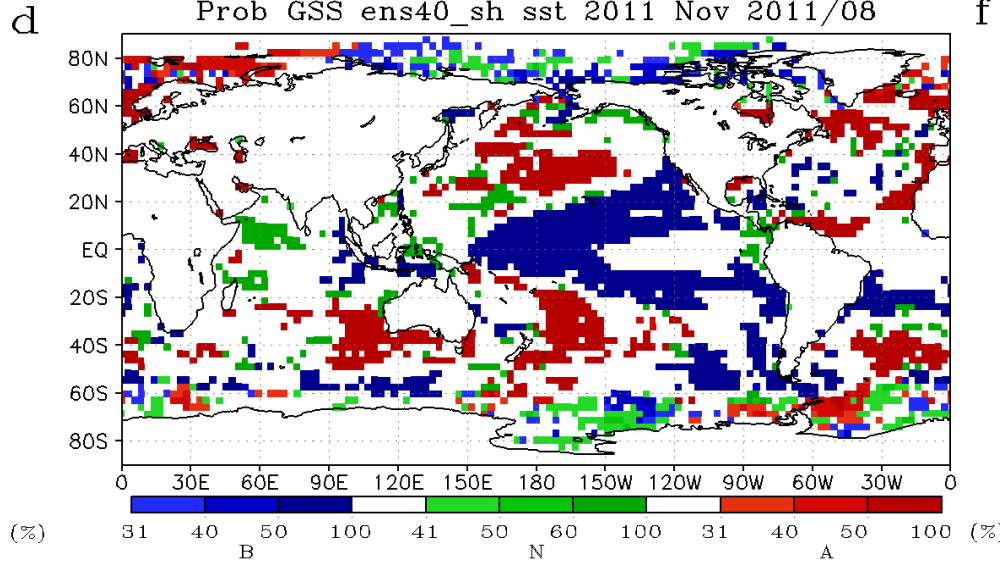
Forecast~ Sep 2011



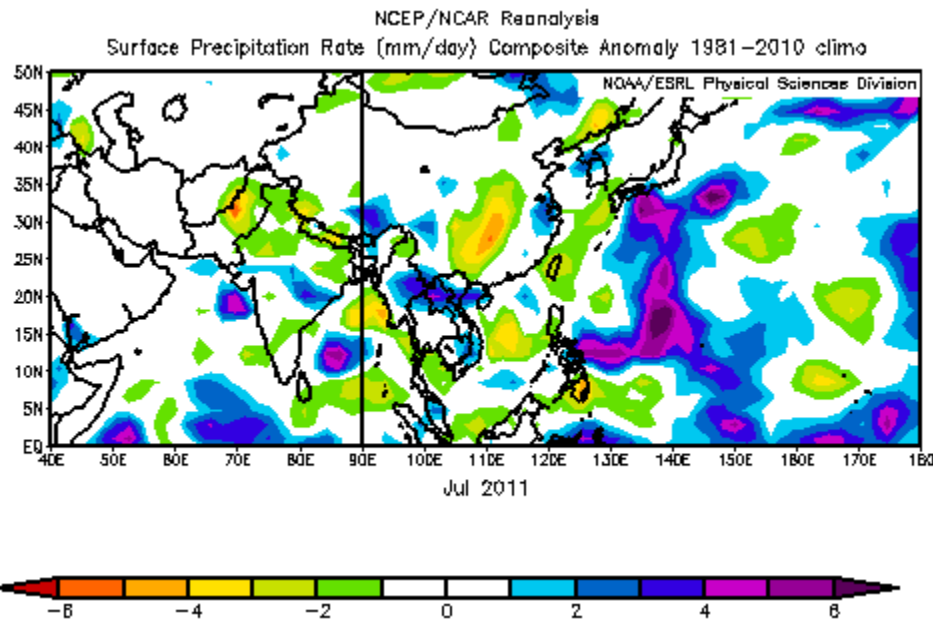
Forecast~ Oct 2011



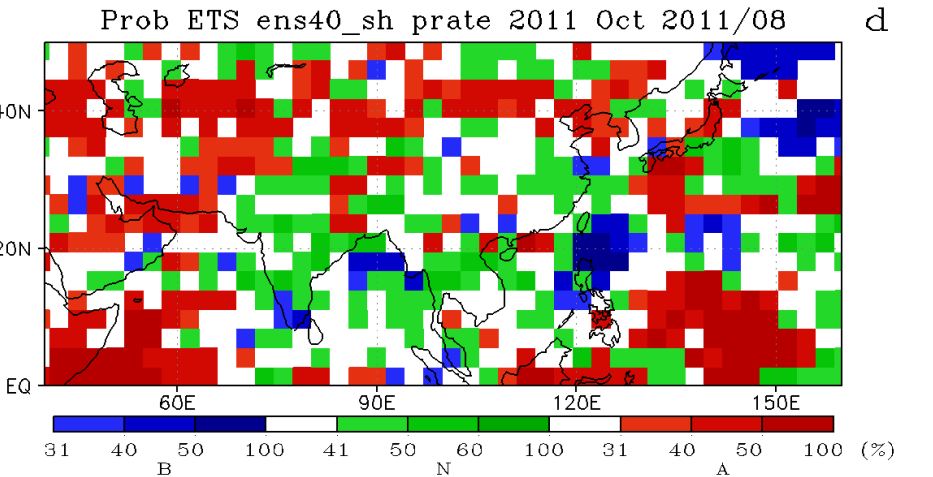
Forecast~ Nov 2011



Precip Rate: Jul 2011 (lead 0)

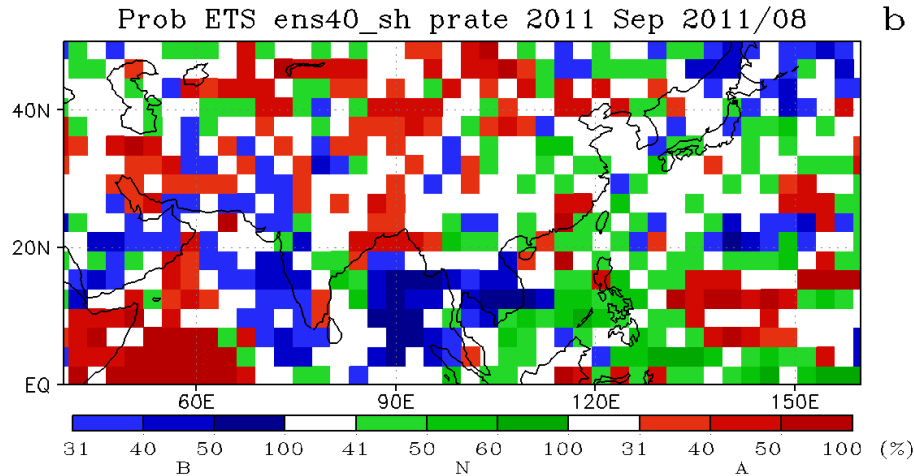


Forecast~ Oct 2011

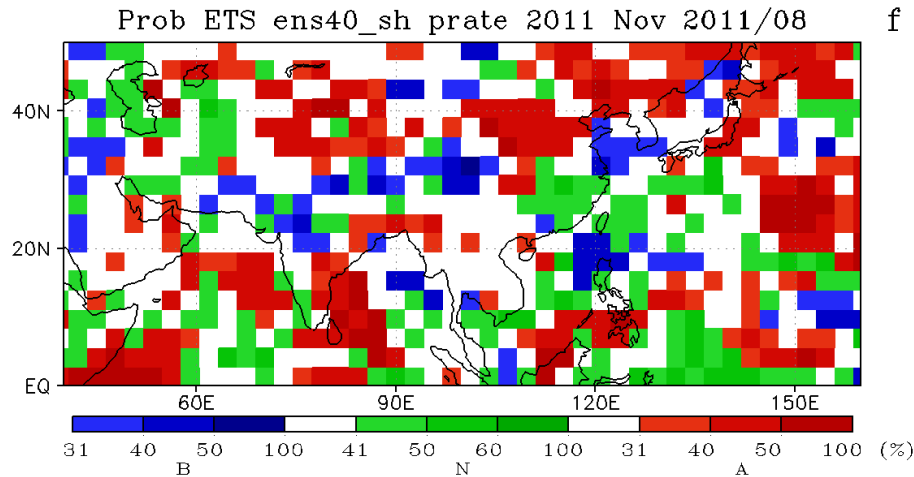


Rainfall Anomaly

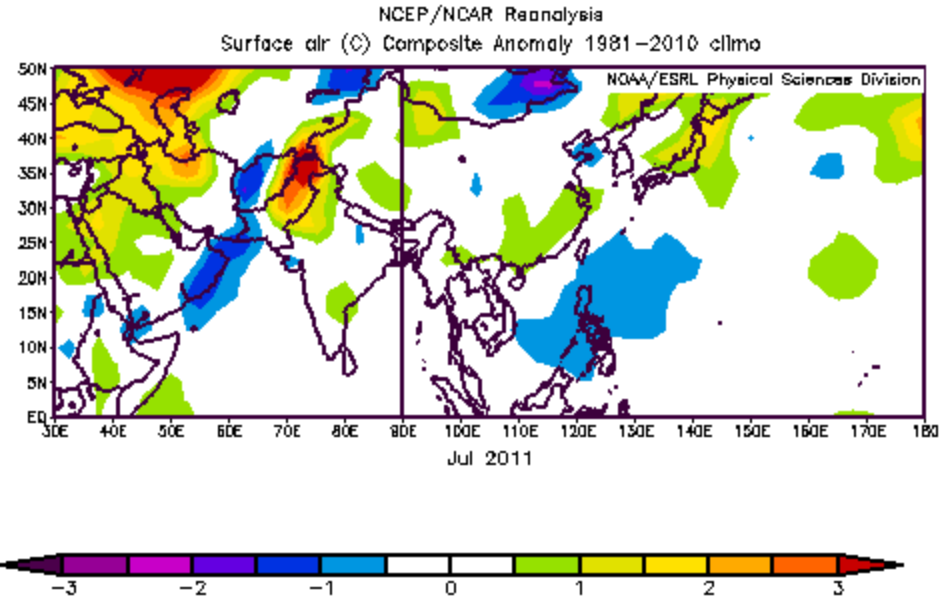
Forecast~ Sep 2011



Forecast~ Nov 2011

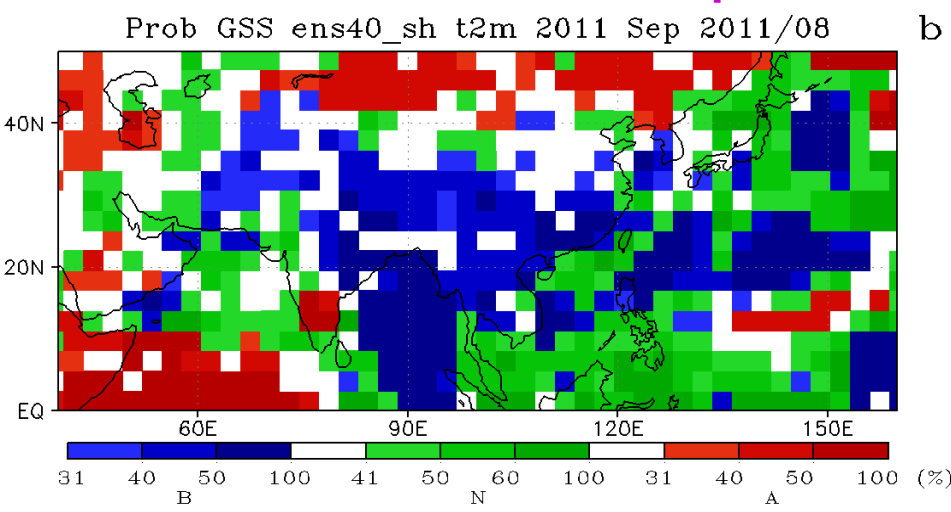


Sfc Temp: Jul 2011 (lead 0)

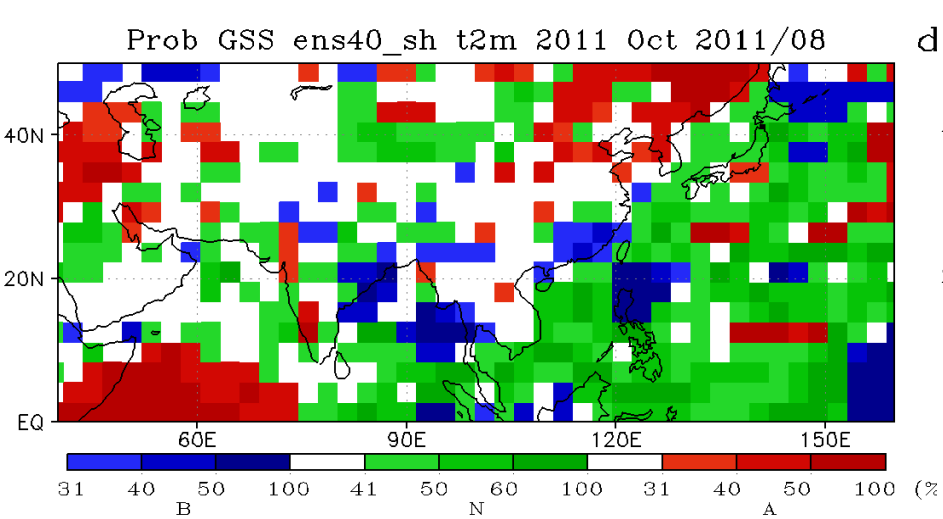


2-meter Air Temperature Anomaly

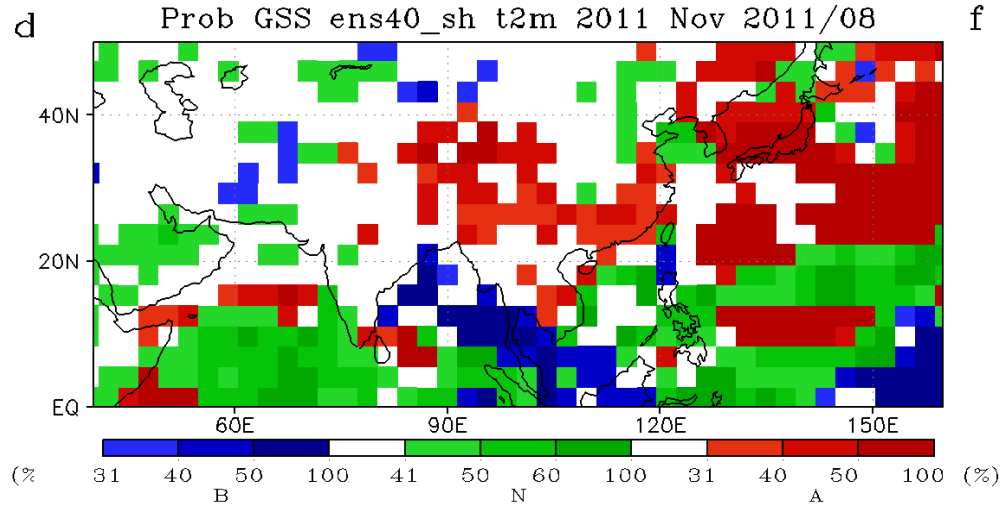
Forecast~ Sep 2011



Forecast~ Oct 2011



Forecast~ Nov 2011



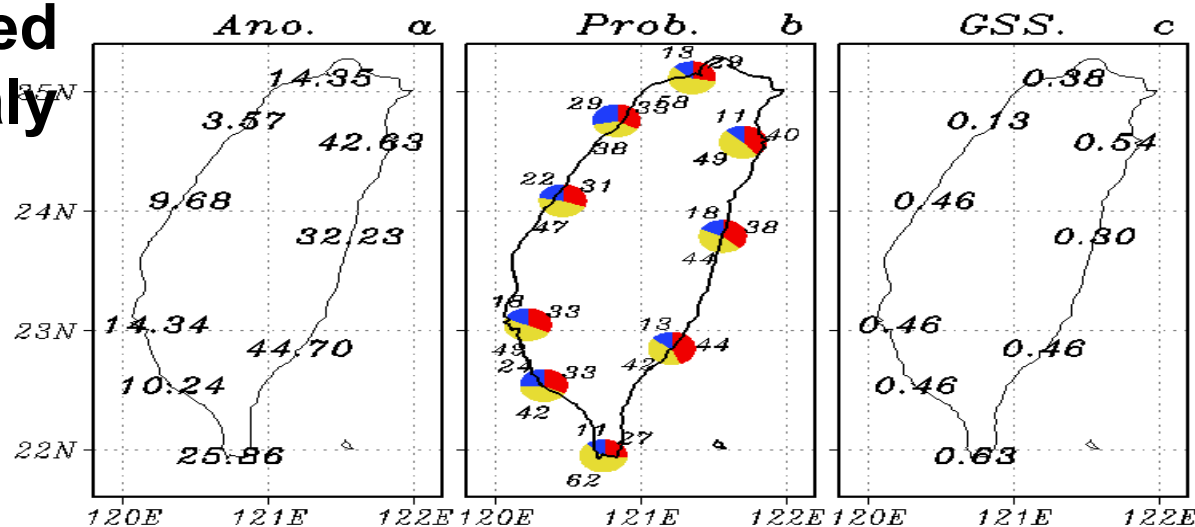
Statistically Downscaled Taiwan Rainfall Anomaly

Above — red

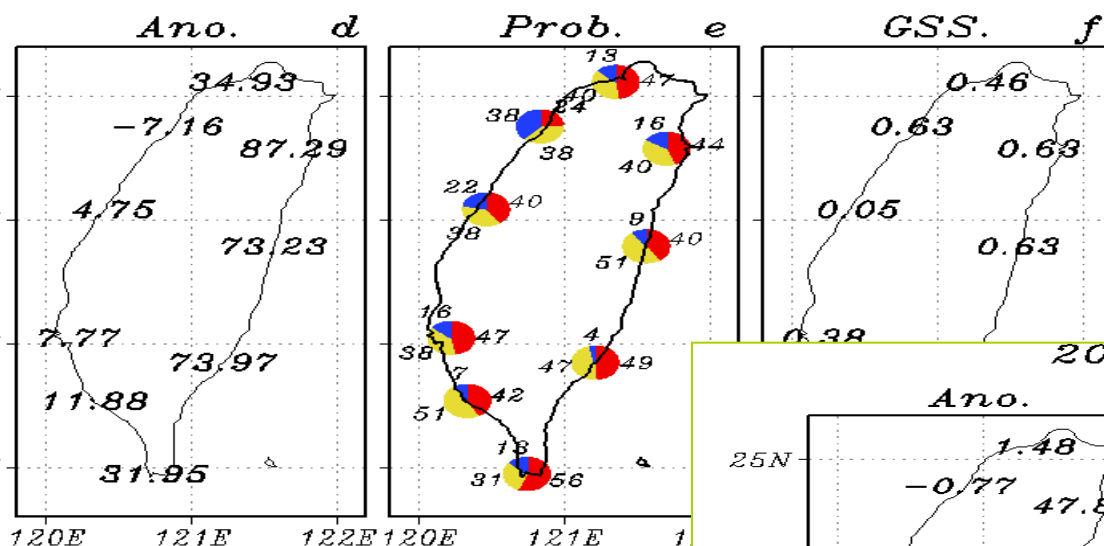
Normal — yellow

Below — blue

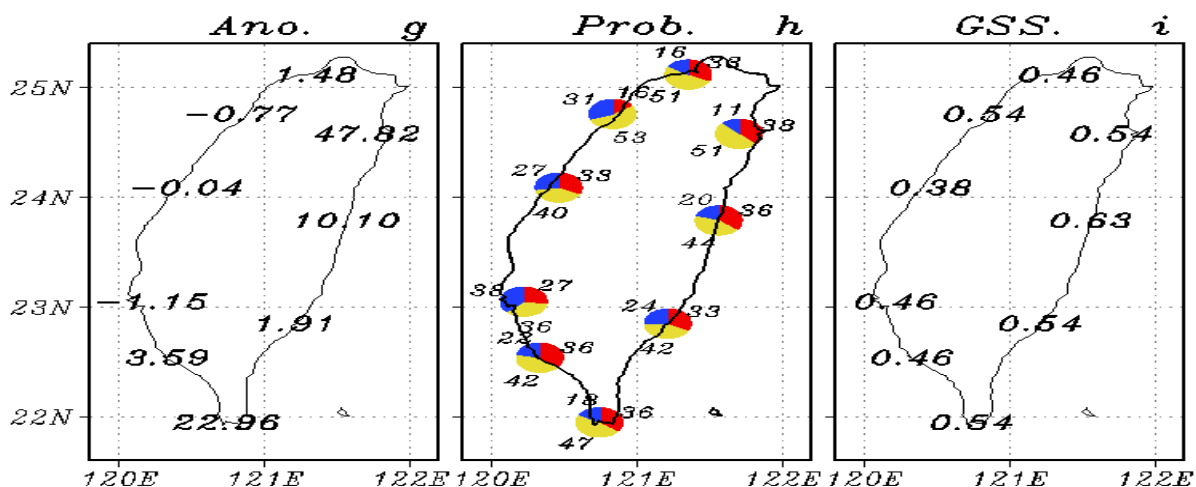
201108Sep Precipitation



201108Oct Precipitation



201108Nov Precipitation



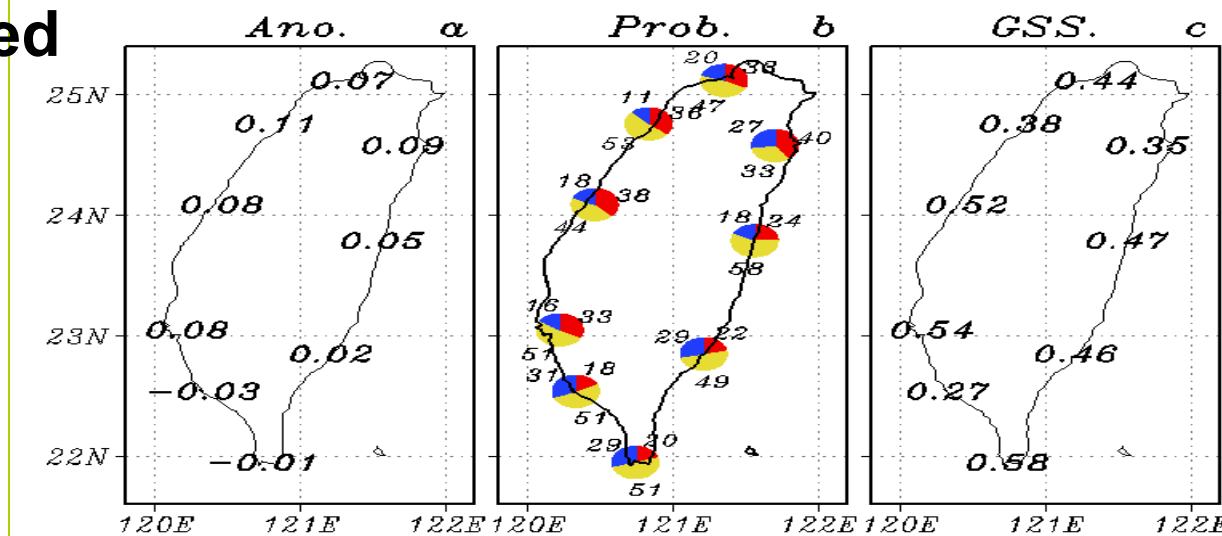
Statistically Downscaled Taiwan Temperature Anomaly

Above — red

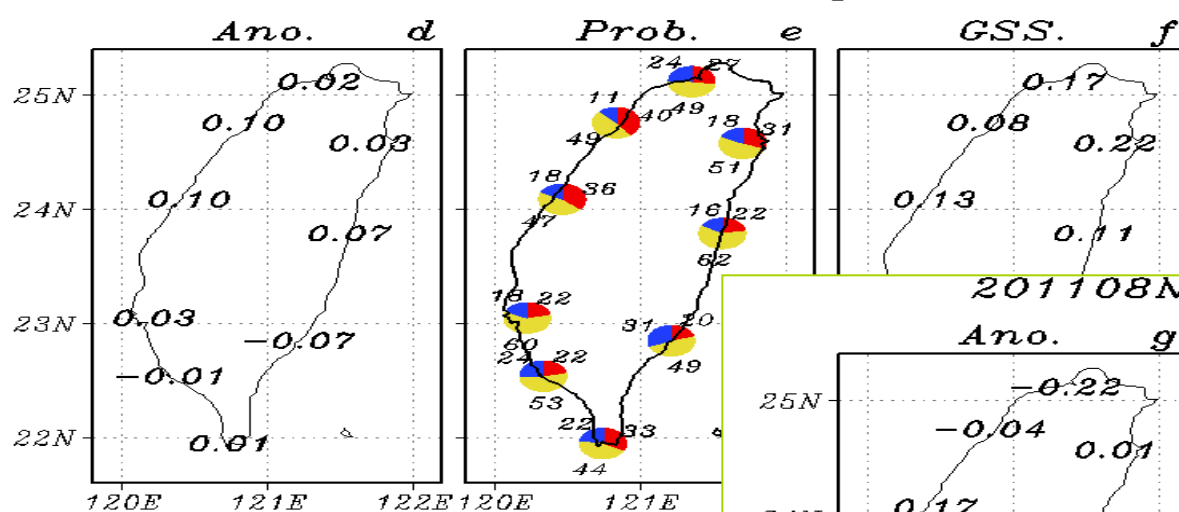
Normal — yellow

Below — blue

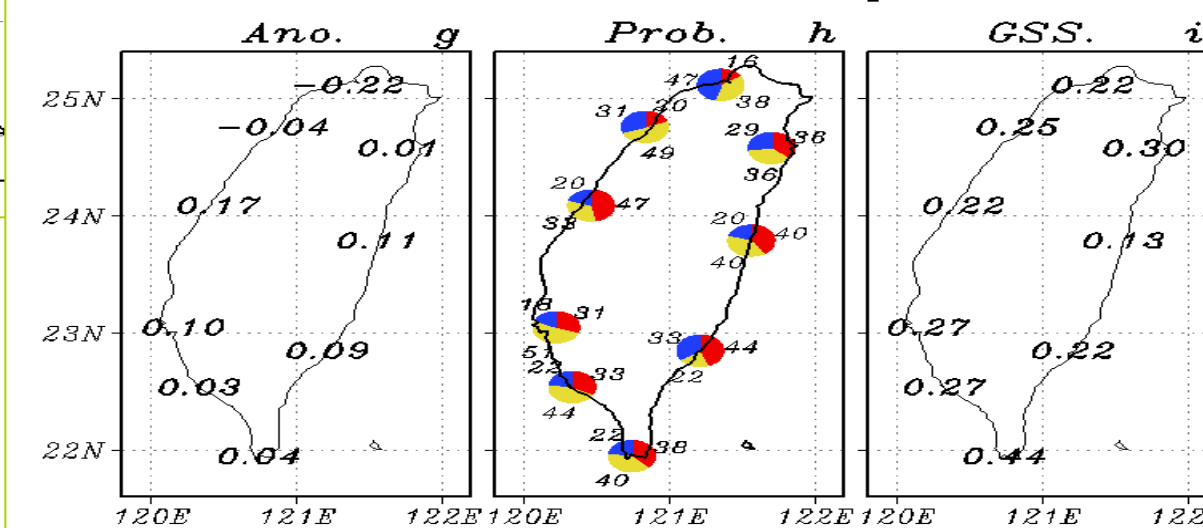
201108Sep Station Temperature

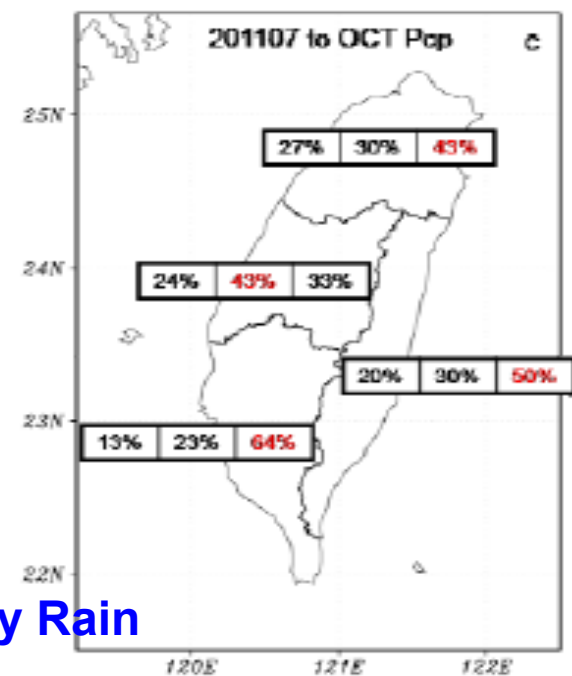
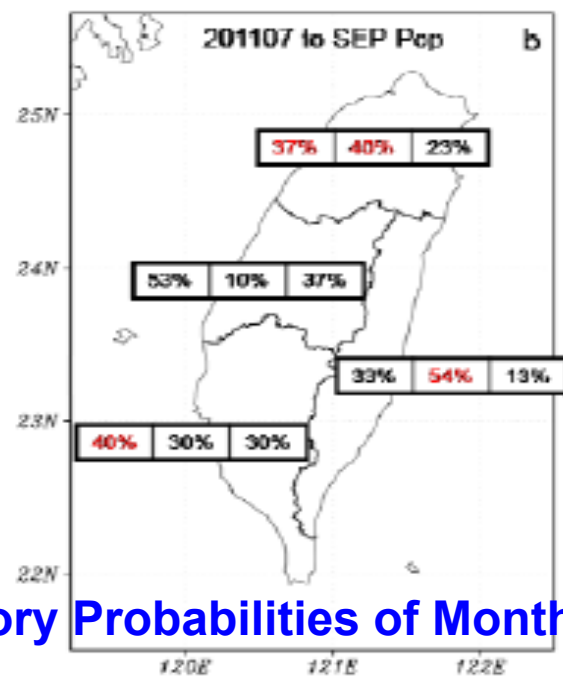
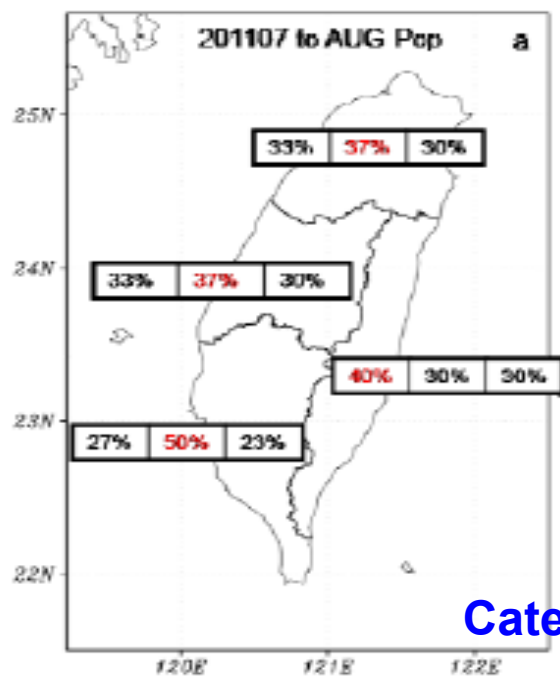


201108Oct Station Temperature

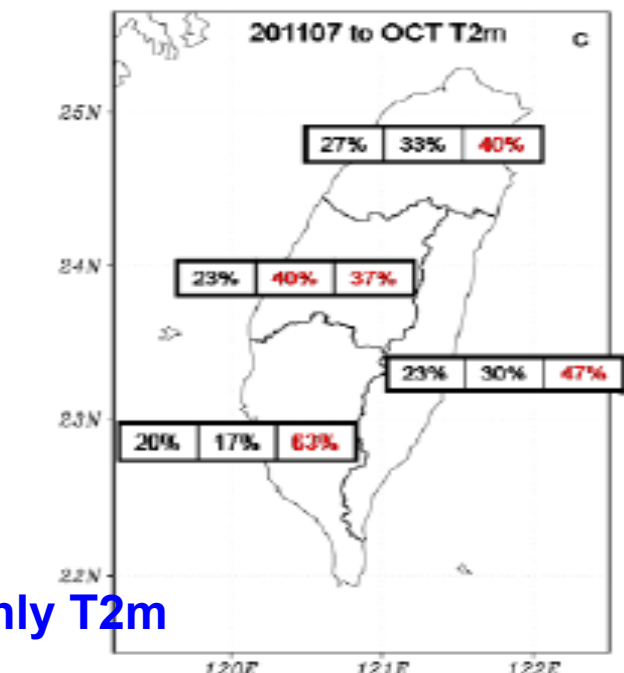
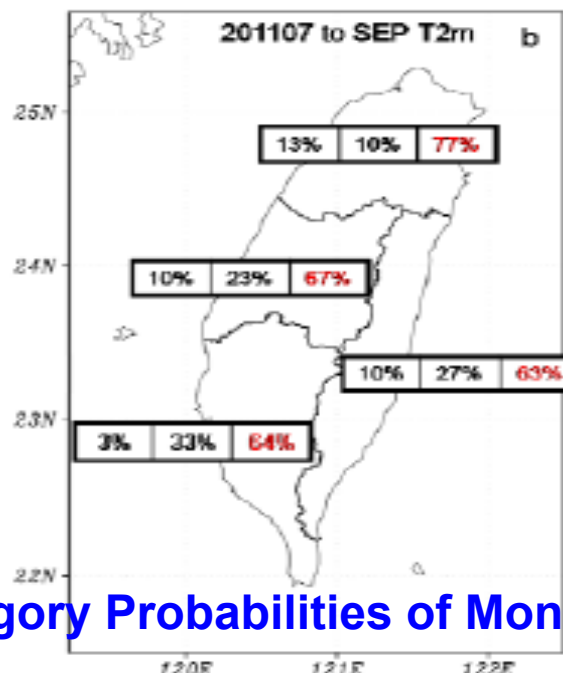
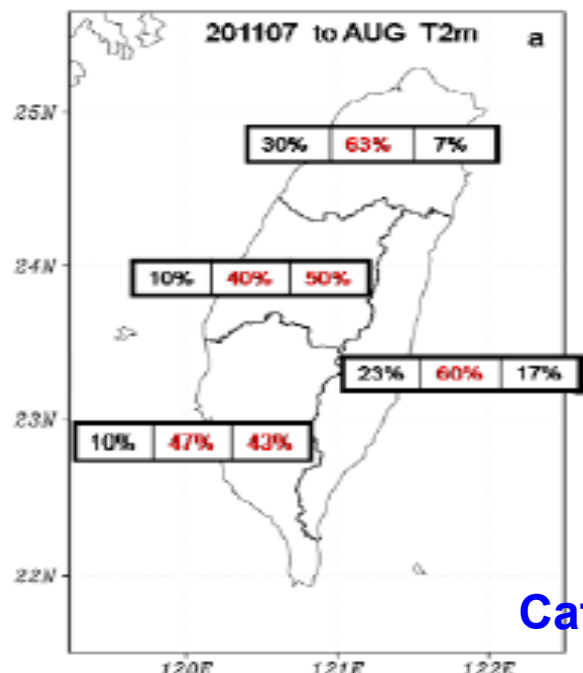


201108Nov Station Temperature





Category Probabilities of Monthly Rain



Category Probabilities of Monthly T2m

The Monthly-to-Seasonal Climate Forecast System Development (II)

2010~2015

• CWB CFS Improvement/Development

- Move toward a **seamless forecast system** – use a lower-resolution version of NWP operational AGCM for monthly-to-seasonal forecast **NWP: T319L40**
CWB 2-T CFSv2: T119L40
- Update forecast initial condition – use **CFSR**
- Improve MME strategy – include NCEP CFSv2 forecasts in CWB 2-tier CFSv2 (**feasibility ?**)
- Develop a **one-tier climate forecast system** – replace the AGCM in NCEP CFSv1 by CWB' s AGCM (**collaborator - NCU**) **CWB 1-T CFSv1: T119L40+MOM3**

Attribute	T119L40	T42L18
Radiation	Unified two-stream calculation with K-correlated method (Fu and Liou 1992, 1993; Fu et al. 1997)	Harshvardhan et al. (1987)
Cumulus Convection Parameterization	Simplified Arakawa-Schubert (Pan and Wu 1995)	Relax Arakawa-Schubert scheme (Moothi and Suarez 1992)
Grid-scale Precipitation	Predict cloud water scheme (Zhao and Frederick 1997)	Diagnostic method (RH value)
Shallow Cumulus Convection	Li and Young (1993)	Li (1994)
Boundary-layer Parameterization	First-order nonlocal scheme (Troen and Mahrt 1986)	TKE- ϵ scheme (Detering and Etling 1985)
Land Model	NOAH (Ek et. al. 2003)	Bucket method (Manabe 1969)
Surface-layer Parameterization	Similarity theory (Businger 1971)	Similarity theory (Businger 1971)
Gravity wave drag	Palmer et al. (1986)	Palmer et al. (1986)

CWB 2-T CFSv2 Development & Data Requirements

✓ CWB **OPGSSTv2**
ready

✓ **SDS** strategy decided

✓ I.D.C. (MJJ) - ready
for Summer hindcast

✓ **MME** strategy
decided

✓ **Spring** (I.C.-
DJF) hindcast &
SDS 1981-2010
evaluation

✓ **Summer** (I.C.-
MJJ) hindcast & SDS
1981-2010 evaluation

✓ **Fall&Winter** (I.C.-
ASO) hindcast &
SDS 1981-2010
evaluation

Dec11

Dec12

Dec13

Dec15

✓ T119L40
50-yr AMIP
evaluation

✓ Initial data
Collection
(I.D.C.) (DJF) -
ready for
Spring hindcast
1981-2010

✓ CFSv2 Reforecast
(initial: DJF) data
collection 1979-2009

✓ I.D.C. (ASO) -
ready for Fall&Winter
hindcast 1981-2010

✓ I.D.C. (MA,N) -
ready for Mei-
Yu&Spring hindcast
1981-2011

● **Initial Data**
Collection Complete

✓ CFSv2
Reforecast (initial:
MJJ, ASO,MA,N)
data collection
1979-2009

✓ **MME Forecast**
Spring (I.C.- DJF)
hindcast evaluation

CWB 2-T CFSv2
Ready for
Operational

● **CFSv2**
Reforecast Data
Collection
Complete

FINALLY...

Archive (Reanalysis / Reforecasts) Requirement:

- CWB would like to use the Archived Reanalysis (CFSR) data (1981-2010) for building the reforecast data base of CWB 2-Tier CFSv2.
- CWB plans to start the reforecast runs in 2012 and to complete the 30-year reforecast in early 2014.
- CWB would like to get NCEP CFSv2 Reforecast (CFSRR) data for forecast comparison and MME forecast system development for both monthly-to-seasonal and 2nd week forecasts.

The Reforecast data of interest are 36 members per month with selective fields. The 36 members consist of 12 members of 9 month runs and 24 members of 45 days runs.

Archive (Real time) Requirement:

- CWB would like to use the Real Time analysis data, consistent with CFSR, as the **initial condition** for the operational runs of CWB 2-Tier CFSv2.
- CWB would like to use the Real Time forecast data, consistent with CFSRR, as members of CWB MME forecast system.

NOMADS Requirement:

For the aforementioned purposes, CWB will need the following help from NOMADS.

- 1) The ftp option and inventory files for “Climate Forecast System Initial Conditions” at <http://nomads.ncdc.noaa.gov/data.php?name=access#cfsr>
- 2) The ftp option and inventory files for “Hourly, Pressure, Fluxes, and Ocean Data” under “Climate Forecast System Reanalysis” at <http://nomads.ncdc.noaa.gov/data.php?name=access#cfsr>

THANK YOU



Process	CWB 2-tier CFSv1	CWB DDFS
Initial Obs. Data Sfc. & Atmosphere	NCEP Analysis - ❶ GDAS ❷ R1; ❸ OI SST	<div> IRI Global Forecast (15 members) </div>
SST Forcing	❶ NCEP CFSv1 SST ❷ CWB OPGSST	
Input Data Pre-process	data interpolation & initialization (hydrostatic adjustment ECHAM)	
Global Forecast	❶ CWB-GFS/NCEP-SST ❷ CWB-GFS/OPGSST ❸ ECHAM5/NCEP-SST ❹ ECHAM5/OPGSST 10x4=40 members	
Regional Downscaling	SVD-based downscaling to 9 Taiwan stations	❶ CWB RSM (60km) ❷ NCEP RSM (60km) 15x2=30 4 Taiwan regions -
Forecast Result Post-process	<ul style="list-style-type: none"> ensemble mean • anomalies • tercile category 	<ul style="list-style-type: none"> ensemble mean • anomalies • tercile
Final Forecast Products	<ul style="list-style-type: none"> ➤ T, Prcip. - • ensemble mean • anomalies • tercile category ➤ Large-scale SLP, U,V,T,Z - • ensemble mean • anomalies 	<ul style="list-style-type: none"> ➤ T, Precip. - • ensemble mean • anomalies • tercile
Forecast Dissemination	http://www.cwb.gov.tw/V7/climate/climate_info/forecast/forecast_4.html	http://www.cwb.gov.tw/V7/climate/climate_info/forecast/forecast_5.html